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LOGIC AND PROBABILITY IN PHYSICS[1]

By Dr. CHARLES GALTON DARWIN

MASTER OF CHRIST'S COLLEGE

THE history of the development of physics in the first quarter of the twentieth century will rank as one of the greatest in the advancement of knowledge, but it will also rank as one of the most curious in the history of human thought. In 1901 Planck started the quantum theory. Even this was curious. He was trying to find out the law of complete radiation by the use of ordinary statistical methods, and observed that he got his answer at what should have been the last stage but one of his work. The last stage would have involved proceeding to a limit, and he found that he got the experimental answer without doing so, and an absurd answer if he did. The work went rather deep into statistical theory and there were many for long afterwards who were not convinced of its compelling force, but it was the great merit of Planck that he knew that he had got something involving a quite revolutionary idea—the quantum. In succeeding years other phenomena were seen to involve the same revolutionary idea: Einstein's theory of the photoelectric effect and of the ionization produced by x-rays, his theory of specific heats, later improved by Debye, and Bohr's theory of spectra. All these things fitted in quite obviously with the quantum, but quite as obviously they violently contradicted the physics of the nineteenth century. What should a man think about a beam of light which according to Einstein had to be composed of arrows, whereas a hundred years earlier Fresnel had *proved* that it was a sys-

[1] Concluding portion of the address of the president of the section of mathematical and physical science of the British Association for the Advancement of Science, meeting at Cambridge from August 17 to 24.

tem of waves? What does a rational being do when faced with two mutually contradictory but both indubitable pieces of evidence? It was a nice test for the critical spirit, and it revealed a wide divergence of choices. In making a historical judgment long after the event, one of the hardest things to do is to recall the relative scale of importance which contemporaries were inclined to attach to the different branches of their subject.

The statistical theory of matter had already been well established by the work of Maxwell, Boltzmann and Gibbs, but it was not regarded as an essential part of a general mathematical-physical education. For example, in the various courses I was advised to undertake during my undergraduate career, no one at any stage ever suggested to me that I should learn anything about the kinetic theory of gases. I think that that period was one when the Cambridge mathematical school was not at its best, and very probably a little more was done at other places, but, to judge by the available text-books in any language, statistical theory was not regarded as one of the prime subjects of study, as it would be now. The period was essentially dynamic, and as such it was moderately easy for it to take in the new ideas of relativity, to which indeed the experimental work of the last century had been leading. But there was no common habit of thought on statistical lines, and so there was a sharp separation of opinion. The seniors, impressed with the vast mass of successful physics of the nineteenth century, with only a rather general knowledge of statistical theory but no facility of thought in it, found the new ideas completely contrary to their convictions. Such men would think that these ideas depended on the difficult and unfamiliar conceptions of statistics and would be inclined to judge that there must be a fallacy in the statistics which would be cleared up later. On the other hand, the laboratory workers, dealing with atoms and electrons from day to day, could not fail to be more impressed with the discontinuous phenomena and the beautiful way these could be explained by the quantum. Such men would cheerfully accept the Bohr orbits as a complete explanation of the hydrogen spectrum, and certainly in many cases would be actually ignorant of the difficulty, the monstrous absurdity, of supposing that a sharp jump from one orbit to another could be responsible for a train of waves shown by the spectroscope to be lasting for quite a long time. So the majority of rational beings behaved in the natural human way of managing to forget all the disagreeable facts. But not every one, for there were Bohr and other leaders who recognized the difficulties on both sides but could still maintain an attitude of balance and could believe that from somewhere there would come a higher synthesis by which everything would be fitted together.

As time went on the quantum got obviously stronger and stronger, and began to invade more fields. The nuclear atom in the hands of Bohr showed itself capable of giving all the broad details of the periodic table of chemistry, still with nothing done to meet the awful difficulties of optical theory. But about 1925, guided by the correspondence principle, things were moving towards a tentative theory of the refractive index, and it was this that finally suggested the break in the contradictions. Acting on a hint given by the theory of refraction, Heisenberg was led to the suggestion that the contradictions of atomic theory would disappear if one adopted the idea of non-commutative algebra in dealing with the motions of electrons in an atom. Then the floodgates broke and the whole new quantum theory burst forth. It would of course be an incomplete account of it not to mention the quite different approach made independently by de Broglie and Schrödinger. If we are to trace this to its origin we must go back a century to Hamilton, for it was his work in geometrical optics which showed how a wave of short wave-length could be treated as a ray. It was de Broglie who worked out the modern analogies, but it was Schrödinger who succeeded in giving its full form, and by the invention of the *wave-function* placed in the hands of the mathematicians the most powerful of weapons for the technical discussion of atomic problems.

At first the work was of a formal kind, obviously right, and a complete synthesis of the rival doctrines of particle and wave mechanics, but there is a very interesting point that has gradually emerged in connection with the discovery. In his first paper Heisenberg laid great stress on the idea of building theory only on directly observable quantities. It is not very clear how the distinction was drawn. The electron's orbit is certainly not observable, but is it less so than the electric force which is the amplitude in the light-wave emitted by the atom? It has seemed to me that it was not this idea of using the observable that was the merit of his work, but rather the contrary—the capacity for carrying through a formal mathematical analogy without ever asking what it all meant in terms of observable things. However that may be, it was only a year later that he remedied the defect by making a picture of his process by means of the uncertainty principle. I may remind you that the uncertainty principle asserts that it is impossible simultaneously to measure the position and velocity of any body, because the measurement of either inevitably produces a change of indeterminate amount in the other. The subject has been so often discussed that I am not going into it now, but as it concerns the center of my argument, I want to emphasize its negative side, which as I think is much the most important. In this rôle the uncertainty principle is to be regarded

as the argument used to defeat the old-fashioned physicist who claims that there is at any rate ideally no limit to the accuracy with which both position and velocity can be simultaneously measured. He has to admit the correctness of experiments such as the Compton effect, and we show him that by his own admission he will be defeated. On the positive side the principle is not so useful, because once we have seen the reason for the failure of classical ideas, we had better take advantage of the full technique of the quantum mechanics. Here my point is that the uncertainty principle showed up a fallacy in the old arguments about causality, and it was a fallacy about which we were so unconscious that we did not even know we were making it. It is now easy to see that there was nothing wrong with the old inference that if I know all about the present I can forecast the future exactly; the trouble was the impossibility of knowing the present. Once this is seen the whole argument becomes obvious, but nobody saw it until Heisenberg. We had somehow to avoid the compulsory causality of the old mechanics, and there seemed no loophole allowing us to do so until the uncertainty principle. Knowing what we now know we may ask why no one discovered the loophole by applying a strict analysis, for example, by the use of symbolic logic. Such an analysis would presumably have revealed the fault, but the trouble is that it would also have revealed other unwarranted assumptions which we have made but which we do not in the least want to doubt, so that it would not really have helped in pinning down the exact point of error. It is invention, not criticism, that leads to the advance of knowledge.

Following up the later history of the subject, the success of Heisenberg in exploiting the idea of observables for atoms seemed to repeat the brilliant success of Einstein twenty years earlier in using the same idea over relativity. It seemed to imply that what was wanted in physics was to free ourselves of all abstractions and only make theories about real things. There grew up a great cult of doubting the reality of unobserved things, and then a curious thing was found; the charm did not work again, and only a few minor things have come out of it. The work of the new quantum theory has in fact run most surprisingly in the opposite direction. The technique is largely concerned with wave-functions, which are quantities much more abstract than anything in classical mechanics. There is certainly nothing observable, or even picturable, about waves propagating themselves in many-dimensional space with absolutely unknowable phase, and with intensity controlled by the curious extraneous rule of normalization. Largely by the use of these wave-functions the whole of atomic physics has been reduced to order, and so has molecular physics, except that it yields problems in which so many electrons are interacting that a full discussion is not feasible. So the doctrine of theorizing only about observables was not really a useful doctrine; it merely provided a germinating idea. In fact, we may well ask what an observable is, and if we go at all beyond direct sensations, which as physicists we certainly intend to do, the answer becomes perfectly indefinite. This opinion I heard admirably expressed a few years ago by the late Professor Ehrenfest. It was in a physics meeting in Copenhagen and some one was proposing a way out of certain difficulties which involved, as he maintained, a reversion to the cult of the observable. Professor Ehrenfest said: "To believe that one can make physical theories without metaphysics and without unobservable quantities, that is one of the diseases of childhood—*das ist eine kinderkrankheit.*"

I have dwelt at some length on the history of the quantum theory because I think it serves as an analogy to the deeper question of what is wrong with the old logical processes. Just as we used to feel the all-pervading compulsive force of causality, so we feel the all-pervading force of pure logic. Just as we felt that classical mechanics provided no room for anything beyond itself, so we feel that the old logic is the only admissible kind of reasoning. We know that certain things led to the old quantum theory and obstinately refused to fit into mechanics, and we know that the principle of probability can cover many things outside the old logic. Many men tried to force the quantum theory into the classical system, and many are still trying to bring probability within the fold of the old logic. I do not believe it can be done. This is not the occasion, nor have I the capacity, for a deep argument on the place of probability in logic, but one of the most convincing ways of seeing it may be found in the consideration of another branch of physical theory, the kinetic theory of gases.

In the early days of kinetic theory the central problem was the law of distribution of velocities of the molecules and attempts were made to prove the law absolutely from dynamics, but the process always failed. Maxwell made the assumption that with the lapse of time a system of molecules would pass through all possible phases. There are technical difficulties in the discussion of this assumption which have never been overcome, and it is quite uncertain if it is even true. Indeed Kelvin, who disliked the whole kinetic theory, argued with some force that the only examples any one could give contradicted the principle—for example, the motion of the planets. The greatest contribution to the subject was that of Gibbs, who recognized that there had to be a big assumption somewhere and made it quite frankly and without attempt at justification. The works of Gibbs are not easy reading; in both his great works he attends to every detail

with a particularity that is really rather tedious, whereas his basic ideas are thrown at the reader almost without explanation. The idea of a canonical ensemble is a really beautiful idea once you understand it, but where does it come from? An ensemble is an idea which will be unfamiliar to many, so I had better explain it. We want to know something about the behavior of a complicated system composed of a great many parts; say we want to know the pressure of the gas in some vessel. If we tried to attack the question by pure mechanics, we should be faced with an enormous number of mechanical equations for the motions of the molecules, and even if these could be solved the solution would be of no use, because it would depend on the initial positions and velocities of the molecules, and these we should not know. Instead of trying this impossible and useless task, Gibbs considers a very large number of possible states of motion of the set of molecules, which have some character in common, such as their total energy, but which are otherwise unrelated. Though each specimen of the motions is quite independent of all the others, he looks at them all together; this explains the word *ensemble*—I do not know why he had to take a French word—and makes the assumption that the pressure of the gas is correctly given by the average of all the specimens. The actual gas in the vessel at any instant is one of the specimens; in its motion it passes into configurations corresponding to others, but only after a fantastically long time would it go through even a perceptible fraction of the whole ensemble. Gibbs is assuming that the behavior of the actual gas will be determined by the average of the uncountable millions of specimens in the ensemble. Almost at the start one finds oneself presented with the ensemble with hardly an attempt to explain where it comes from or why it is right, and the beginner is usually troubled by the fact that, though the subject is obviously mechanical, all the mechanics he laboriously learned in his youth seem to have faded into comparative unimportance. There are various kinds of ensemble, the chief of which is the canonical, corresponding to all the possible motions of the gas which would have the same temperature. Later, almost as a concession to human frailty, Gibbs introduces the micro-canonical ensemble, composed of much fewer specimens becausee they all have exactly the same energy. This is usually welcomed by the beginner because it seems closer to his familiar mechanics, but with more experience he will realize that the gap is still so great that he is really no better off, and he may as well accept the more general idea at once.

With the old mechanics all this involved ideas which for many readers were distinctly hard to accept. The principle of probability, embodied in the averaging over the ensemble, was frankly laid on top of the logical principles of Newtonian mechanics, and to any one believing that probability would ultimately be brought down to the old logic the association was most repellent. But we can now see that Gibbs was a prophet far ahead of his time—and indeed, to be frank, far ahead of his own knowledge—for the new mechanics accommodates the ensemble very much more easily than did the old. The new mechanics has shown us that it is impossible to know how the individual molecules are moving, because when one undertakes an experiment to see, that experiment automatically alters the condition of the gas and so fails to tell what was wanted, the state of the molecules without the experiment. In the old days one used to feel that the validity of Gibbs's idea would be spoiled by some skilful experimenter who would really observe the motions of the individual molecules and would therefore rule out the legitimacy of averaging over the *whole* ensemble, but we now know that there is no danger of this. The real gas in the vessel is not merely one specimen of the ensemble, unrecognizable only because of our clumsiness; it is itself the whole of the ensemble. We used to think of the gas as *either* in the state A, *or* in the state B, *or* in C, but according to the new physics we have to think of it as in *all* the states A *and* B *and* C. The distinction is typical of the change we must make in our habits of thought, and most of us resist this change strongly, for we find we can hardly help asking: "But which state was it really in?" As I have said, we used to be ashamed of ignorance, but we must now realize that *this* ignorance is one of the things that makes the world possible. The principle of probability, which used to be loosely superposed on the old logical principle, is now with the new mechanics fully united with it in a higher synthesis.

Before leaving Gibbs I would like to refer to one thing in his book, where I think he has not even yet come into his own. He considers various types of ensemble of increasing generality. In the micro-canonical the members all have the same energy. Now we never know the exact energy of the gas in a vessel, so that a better idea is the wider one of a gas at a given temperature, which therefore has a certain range of admissible energies. This is represented by Gibbs's canonical ensemble, and it is the main one that he uses. In both these the number of atoms in the ensemble is constant. But in the last chapter of his book Gibbs introduces a still wider ensemble. He calls the ones with a constant number of atoms *petits ensembles,* which I shall translate as petty ensembles, and regards them as parts of a grand ensemble in which the total number of atoms is not fixed. He uses the idea to some extent in connection with semi-permeable membranes, but on the whole does not get far with it. As in much of Gibbs's work, it is the idea

itself, rather than what he does with it, that is important. This idea of the grand ensemble is not yet incorporated in the new physics. In the quantum theory we take a number of electrons and nuclei and, allowing for their interactions, we construct something that is practically the canonical ensemble. But we take fixed numbers of them—this is partly reflected in the technical process of using normalized wave-functions. Now in an experiment dealing with a large number of particles we are never really sure exactly how many there are, and to assume this number is much like assuming a constant energy for them. If the canonical ensemble is a better idea than the micro-canonical, then the grand ensemble is superior to the petty ensemble. In the new mechanics nobody has yet succeeded in making anything of it, or has made any proposal how to do so, but I will venture to forecast that when some of our present difficulties in the quantum theory are cleared up, it will be found that we shall be using the grand ensemble with its indefinite number of atoms.

Reverting to my main theme, what is the moral of all this? It is that the new physics has definitely shown that nature has no sharp edges, and if there is a slight fuzziness inherent in absolutely all the facts of the world, then we must be wrong if we attempt to draw a picture in hard outline. In the old days it looked as if the world had hard outlines, and the old logic was the appropriate machinery for its discussion. Things went wrong when it was found necessary to call in the help of the principle of probability; this appeared first as an alien, but there was hope in the old days that the alien might be naturalized. It has resisted the process and we now recognize that it can not be assimilated, because it provides the necessary step to a wider reason, that of the new fuzzy world of the quantum theory, a world which is not contained in the old. How far it will be possible to make a full synthesis of the new and the old I do not know, but I like to think there is something in my analogy from the history of the quantum theory, and to suppose that we are still in the condition corresponding to the old quantum theory, and that some day a real synthesis will be made like that of the new quantum theory, so that there will be only one thing in the world that has not indefinite outlines, and that will be a new reformed principle of reasoning.

I may fitly conclude this part of my subject by returning to the point from which I started. As an example of what the ordinary man regards as correct reasoning I quoted some words of Sherlock Holmes. I must now confess that I was not quite sincere in my quotation; the impression I gave was the impression the reader carries away, but on examining the text I was interested to find that the great detective had himself arrived at the ideas I have been putting forward. In the sentence before he said "No, no; I never guess. It is a shocking habit destructive of the logical faculty," he had said: "I could only say what was the balance of probability—I did not expect to be at all accurate." The master-mind uses the word logic in its modern sense.

There may be a feeling among some that the very general suggestions I have been making are open to every sort of criticism. Perhaps they are right; as I have said, it is part of my doctrine that the details of a physicist's philosophy do not matter much. But whether it is wrong or right, my next point is one on which I do very much hope that there may be a consensus of agreement. This is that the subject of probability ought to play an enormously greater part in our mathematical-physical education. I do not merely mean that every one should attend a course on the subject at the university, but that it should be made to permeate the whole of the mathematical and scientific teaching not only at the university but also at school. To the best of my recollection in my own education I first met the subject of probability at about the age of thirteen in connection with problems of drawing black and white balls out of bags, and my next encounter was not till the age of twenty-three, when I read a book—I think it was on the advice of Rutherford—on the kinetic theory of gases. Things are better now, but mathematicians are still so interested in the study of rigorous proof that all the emphasis goes against the study of probability.

Its elements should be part of a general education also, as may be illustrated by an example. Every month the Ministry of Transport publishes a report giving the number of fatal road accidents. Whenever the number goes up there is an outcry against the motorists, and whenever down, of congratulation for the increased efficiency of the police. No journalist ever seems to consider what should be the natural fluctuations of this number. A statistician answers at once that the natural fluctuation will be the square root of the total number, and apart from obvious seasonal effects that is in fact about what the accidents show; the number is roughly 500 ± 25. The proof of this does not call for any difficult mathematics, neither the error function nor even Stirling's formula, but can be done completely by the simple use of the binomial theorem. There is no mathematical difficulty that should trouble a clever boy of 15; it is only the train of thought that is unfamiliar, and it is just this unfamiliarity that is the fault of our education. The ideas and processes connected with the inaccuracy of all physical quantities are much easier to understand than many ideas that a boy has to acquire in the course of his studies; it is only that at present they are not taught, and so when met they are found difficult.

This is not the place to describe a revised scheme

of education. I would only say that it is not special new courses that are needed, but rather a change in the spirit of our old courses. When a boy learns about the weighing machine, emphasize its sensitivity and consider the length of time that must be taken for the weighing. When he has a problem on projectiles, make him consider the zone of danger and not merely the point of fall. At a rather higher level, but still I should hope at school, introduce the idea of a distribution law; for example, in doing central orbits work out Rutherford's law of scattering. Calculate the fluctuations of density of a gas, or the groupings in time of the scintillations of α-particles. All these things ought to be examples of a familiar train of thought, and not merely a highly specialized side branch of mathematics first met at the university. It is the incorporation of probability in the other subjects on which I want to insist, but there will of course remain some higher aspects—things like least squares or significance tests—which are still to be treated in separate university courses. Even these I should hope would come to be recognized as subjects of central interest and not, as they are at present, relegated to a remote corner of specialized study.

If these reforms are carried out I shall hope that generations will grow up which have a facility that few of us at present possess in thinking about the world in the way which the quantum theory has shown to be the true one. The inaccuracies and uncertainties of the world will be recognized as one of its essential features. Inaccuracy in the world will not be associated with inaccuracy of thought, and the result will be not only a more sensible view about the things of ordinary life, but ultimately, as I hope, a fuller and better understanding of the basis of natural philosophy.

SCIENTIFIC EVENTS

NATIONAL PARKS

PRESIDENT ROOSEVELT has approved a recent act of Congress, marking an important step towards the final establishment of the proposed Isle Royale National Park in the State of Michigan. This act provides that all lands purchased by the Federal Government for conservation or forestation purposes within the authorized park boundaries, with funds heretofore allocated and made available by executive order, or otherwise, shall be made a part of the park as fully as if originally acquired for that purpose.

The establishment of the Isle Royale National Park was authorized by the act of Congress approved on March 3, 1931. Isle Royale, the largest island in Lake Superior, is rich in wildlife and is famous for its copper mines worked by Indians before the advent of white men. It is situated just within the international boundary separating Canada and the United States, being 50 miles northwest of Keweenaw Point, Michigan, and 20 miles southeast of the nearest Canadian mainland at Thunder Cape. Isle Royale measures 44 miles in length and 9 miles in width, including an area of 205 square miles. To date, 102,000 acres of land have been acquired under the executive order, leaving approximately 19,000 acres under contract to be purchased or in condemnation. The State of Michigan, which has appropriated $100,000 toward the acquisition of private rights on the island, must also cede exclusive jurisdiction to the United States over the lands acquired directly by the Federal Government before the park will be fully established.

Two days before his term as Chief Executive expired on March 4, 1909, Theodore Roosevelt by executive order established the Mount Olympus National Monument. An act was passed during the closing hours of the last session of Congress creating the Olympic National Park with the Mount Olympus National Monument as a nucleus. It provides for the immediate inclusion of 634,000 acres, nearly twice the area of the Mount Olympus National Monument, and in addition authorizes the President to add to this acreage lands from the Olympic National Forest and any lands that may be acquired by gift or purchase up to 898,292 acres. The region comprising the park is one of rugged ice-capped peaks and dark but vividly green "rain forests" of giant moss-festooned spruce and fir; of lake-studded flowering meadows forming natural gardens. Through its deep canyons streams fed by the waters of melting glaciers above find their outlet in the Pacific.

Purchase by the Federal Government of the last remaining land needed to complete the Great Smoky Mountains National Park in the wilderness of North Carolina and Tennessee has been announced. The act provides an appropriation for the National Park Service with which it will be possible to acquire 26,000 acres of land in Tennessee. All but the relatively small amount of land remaining to be bought gradually has been acquired since 1926 by the states with private donations and with state and federal funds. Private funds were matched, dollar for dollar, up to $5,000,000 by the Rockefeller Foundation as a memorial to Laura Spelman Rockefeller, mother of John D. Rockefeller, Jr. The Great Smoky Mountains National Park area so far acquired has been under the jurisdiction of the National Park Service since 1930. With the money now available, the final steps can be taken toward completion and formal

dedication of the park. To date title to 410,000 acres within the prescribed boundary is in the name of the United States, of which North Carolina purchased and gave title to approximately 184,752 acres, and Tennessee 165,921 acres. Also 59,394 acres were purchased with emergency funds authorized by executive order, at a cost of about one and a half million dollars, leaving the approximately 26,000 acres in Tennessee, the purchase of which now is possible.

FIELD WORK OF THE PHILADELPHIA ACADEMY OF NATURAL SCIENCES

EIGHTEEN expeditions and field projects have been carried on for the Philadelphia Academy of Natural Sciences during 1938, which include the following:

Jacques Francine, of Philadelphia, lived four months during the late winter and spring with a party of Swampy Cree Indians in the inaccessible wilderness of the Labrador Peninsula collecting mammals. He and Paul Millard, a French trapper, were flown by airplane some five hundred miles north of Quebec in the middle of last March. Arriving at the Crees' encampment, they shared with them the hardships of short rations and 40 below zero blizzards until the spring thaws made it possible for the group to migrate by canoe down the unmapped Kowashamiska River, about the size of the Connecticut River, south to the Hudson's Bay Post where the Indian furs were traded.

In Mexico, R. R. M. Carpenter, trustee of the academy, collected birds and mammals during March with Harold T. Green of the staff, and H. Radclyffe Roberts is collecting grasshoppers in the highlands north of Mexico City under the auspices of the academy and of the American Philosophical Society.

In the West Indies James Bond continued his survey of bird life and distribution, and at Madagascar, off the coast of Africa, Charles Lamberton is making a collection of insects.

Dr. Edgar B. Howard is carrying on his field researches for early man in North America, both in Florida and at Nebraska. He is accompanied by Malcolm Lloyd and Edward Page, Jr. Dr. Francis W. Pennell, assisted by a grant of the American Philosophical Society, is gathering botanical material in Utah and Colorado; and in Florida John Cadbury made a collection of insects during the month of March.

From Dutch New Guinea, one of the last frontiers of undisturbed wild life, Dillon Ripley returned with a large collection of zoological material, including birds, shells, plants and fish which he collected while a member of the Denison-Crockett Expedition to the southern Pacific.

The R. M. de Schauensee Zoological Survey of Siam is continuing its fourth year of research and the collecting of fish, birds and mammals, and Charles Primrose is doing similar work in India. An expedition sponsored by the academy and the Peabody Museum of Harvard College is seeking traces of early man in northern India, Java and the Philippines. During the past six months George Vanderbilt has continued making collections for the fish department, while he has been at Hawaii and the adjacent islands. In South America, M. A. Carriker, Jr., and Gordon Howes continued their study of bird migrations and distribution in Bolivia, and to the north in Columbia, Kiell von Sneidern is collecting birds.

THE FOURTH INTERNATIONAL CONGRESS OF COMPARATIVE PATHOLOGY

THE fourth International Congress of Comparative Pathology will meet in Rome, from May 15 to 20, 1939, under the official auspices of the Italian Government, with headquarters at the National Council for Researches, Piazzale delle Scienze.

Professor Pietro Rondoni, member of the Italian Academy and director of the Cancer Institute and of the Institute of General Pathology of the University of Milan, is president of the congress, and Professor Vittorio Zavagli, director of the Experimental Station for Animal Prophylactics, Rome, is secretary. The vice-presidents are: Senior Professor Nicola Pende, director of the Institute of Pathology and Medical Methodology of the Royal University, Rome; Professor Alessandro Lanfranchi, director of the Institute of Pathology and Veterinary Medical Clinic of the Royal University of Bologna; Professor Lionello Petri, director of the Institute of Phytopathology, Ministry of Agriculture, Rome, and Dr. Ugo Frascherelli, general secretary of the National Council for Researches, Rome, is the general secretary.

All meetings will be held at the Royal University and at the Institute for Public Health. The official languages will be Italian, English, French, German and Spanish.

The congress, which is of a purely scientific nature, has as its object the comparative study of pathology in human beings, animals and plants, bearing particularly upon diseases common to several groups of organisms and upon general organic reactions, viewing all biological as well as economic and social correlations. It will meet in three sections: Human Medicine, Veterinary Medicine and Phytopathology. There will be reports on ultra virus diseases, heredity in pathology, the function of the associated antigenes and regressive processes in plants.

In order to render more complete and more interesting the study of the various problems and to bring about closer mutual relations among the students of related sciences, the main subjects which are on the agenda will be reported on and discussed before an assembly of all the sections.

The papers sent to the various sections must be related to the main subjects and be as concise as possible. A summary of about one hundred words must reach the secretariat not later than March 31, 1939. The organizing committee will make a final decision in regard to the acceptance of papers. It is provided that it may accept papers bearing upon other subjects, if they are of particular importance and originality.

THE INTERNATIONAL GEOLOGICAL CONGRESS

THE eighteenth session of the International Geological Congress will be held in London from July 31 to August 8, 1940.

At a special meeting recently called by the Geological Society of London and attended by representatives of kindred societies, public bodies and personal donors to the congress funds, it was decided to entrust the preparation and organization of the congress to a general organizing committee. It was also decided to vest the executive authority of the general organizing committee in an executive committee and to recommend to the bureau of the congress that the officers of the general organizing and executive committees be the officers of the congress. These committees were unanimously elected. It was further agreed that the power to add to the membership of the general organizing committee and the executive committee be vested in the council of the Geological Society of London.

Officers of the general organizing committee are:

Honorary President

Sir William Bragg, president of the Royal Society.

Honorary Members

The Right Honorable The Lord President of His Majesty's Most Honorable Privy Council.
The Lord Lieutenant of the County of London.
The Right Honorable The Lord Mayor of London.
The Chairman of the London County Council.
The Chancellor of the University of Cambridge.
The Chancellor of the University of London.
The Chancellor of the University of Oxford.
The Chancellor of the University of St. Andrews.
The President of the Royal Society.
The President of the Royal Society of Edinburgh.
The Director-General of the Ordnance Survey.
The Hydrographer of the Navy.
The Director of the British Museum (Natural History).
The Director of the Royal Botanical Gardens, Kew.
The Right Honorable Viscount Bearsted, chairman of the Shell Transport and Trading Co.
The Right Honorable Lord Cadman of Silverdale, chairman of the Anglo-Iranian Oil Co.
Sir John S. Flett, formerly director of the Geological Survey of Great Britain.
Dr. Alfred Harker, St. John's College, Cambridge.
Sir Thomas Holland, principal and vice-chancellor of the University of Edinburgh.
Sir Albert Seward, South Kensington.
R. I. Watson, Esq., director of the Burmah Oil Co.
Professor W. W. Watts, emeritus professor of geology in the Imperial College of Science and Technology.
Sir Arthur Smith Woodward, Haywards Heath, Sussex.

Officers

Vice-presidents: the president of the Geological Society of London and the director of the Geological Survey of Great Britain.
General Secretaries: Dr. W. F. P. McLintock, deputy director of the Geological Survey of Great Britain, and Professor W. B. R. King, University College, London.
Treasurer: F. N. Ashcroft, London.

No professional title is required from those registering as members of the congress. Nevertheless, the excursions organized before and after the session will be more especially reserved for the members who are geologists, geographers and mining engineers, and for others who devote themselves to the study or practice of some branch of geology.

Proposed subjects for discussion are:

Magnetic Differentiation.
Metasomatic Processes in Metamorphism.
Caledonids in Northwest Europe.
Rhythm in Sedimentation.
The Geology of Iron-Ore Deposits.
The Geology of Coal Seams.
The Geology of Petroleum.
The Geology of Sea and Ocean Floors.
The Stratigraphical Limits of the Ordovician System.
The Pliocene-Pleistocene Boundary.
The Distribution of Early Vertebrates.
Faunal Facies and Zonal Correlation.
Earth Movements and Evolution.
The Geological Results of Applied Geophysics.

An elaborate program of excursions to be taken before, during and after the congress has been arranged. Requests for further information should be addressed to the General Secretaries, International Geological Congress, Geological Survey and Museum, Exhibition Road, South Kensington, London, S.W. 7. The address for foreign telegrams and cables is Incongeol, London.

SYMPOSIA AT THE MILWAUKEE MEETING OF THE AMERICAN CHEMICAL SOCIETY

SYMPOSIA at the meeting of the American Chemical Society, meeting in Milwaukee from September 5 to 9, are reported in *Industrial and Engineering Chemistry*.

The Division of Agricultural and Food Chemistry has arranged a symposium on the Industrial Utilization of Agricultural Products, in which the Division of Biological Chemistry and possibly the Division of Industrial and Engineering Chemistry will co-

operate. In addition a joint symposium on vitamins and another on patents will be sponsored by the division in cooperation with the Divisions of Biological Chemistry and of Medicinal Chemistry. These three divisions have arranged vitamin symposia for the past seven meetings.

The Division of Colloid Chemistry, together with the Division of Physical and Inorganic Chemistry, has arranged a symposium on the Physical Chemistry of the Proteins. Invitations to participate have been accepted by Drs. Langmuir, Cohn, Kirkwood, MacInnes, Eyring, Stanley, Heidelberger, Abramson and Koets. In addition to the symposium on proteins, the Division of Physical and Inorganic Chemistry is sponsoring symposia on the determination of traces—which members of the microchemical division are invited to attend—on liquid ammonia and on nuclear chemistry.

The Division of Industrial and Engineering Chemistry will take part in three symposia as follows: Unit Processes, organized by R. Norris Shreve; Surface Active Agents, with F. E. Bartell as chairman; and Electrical Insulating Materials, organized by the Subcommittee on Chemistry, Conference on Electrical Insulation, National Research Council, with F. L. Miller as chairman.

The Division of Organic Chemistry will cooperate with the Division of Sugar Chemistry and Technology in a Symposium on Nomenclature of the Sugars and Their Derivatives and probably with the Division of Physical and Inorganic Chemistry in the symposium on Reactions in Liquid Ammonia.

THE ANNUAL SUMMER MEETING OF THE AMERICAN MATHEMATICAL SOCIETY

THE forty-fourth annual summer meeting of the American Mathematical Society, to be held from September 6 to 9, at Columbia University, New York City, will be devoted in large part to the celebration of the fiftieth anniversary of the founding of the society. While there will be ten sectional meetings for the presentation of the usual short papers embodying the results of recent mathematical research, the main scientific feature will be the program of invited addresses designed to review some part of the progress of mathematics during the half century of the life of the society. Speakers and their subjects are as follows: R. C. Archibald, Brown University, "History of the American Mathematical Society, 1888–1938"; G. D. Birkhoff, Harvard University, "Fifty Years of American Mathematics"; E. T. Bell, California Institute of Technology, "Fifty Years of Algebra in America, 1888–1938"; G. C. Evans, University of California at Los Angeles, "Dirichlet Problems"; E. J. McShane, University of Virginia, "Recent Developments in the Calculus of Variations"; J. F. Ritt, Columbia University, "Algebraic Aspects of the Theory of Differential Equations"; J. L. Synge, University of Toronto, "Hydrodynamical Stability"; T. Y. Thomas, Princeton University, "Recent Trends in Geometry"; Norbert Wiener, Massachusetts Institute of Technology, "The Historical Background of Harmonic Analysis," and R. L. Wilder, University of Michigan, "The Sphere in Topology." The society is publishing a volume containing these addresses, except Professor Archibald's, under the title of "Semicentennial Addresses." It is publishing also a history of the society by Professor Archibald.

The opening session of the jubilee celebration will be marked by the presence of delegates from over fifty scientific and learned societies, including approximately thirty foreign mathematical societies, those American and Canadian scientific societies whose interests are most closely related to mathematics, and such organizations of general scientific interests as the National Research Council, the National Academy of Sciences and the American Association for the Advancement of Science. The address at this meeting will be delivered by President Nicholas Murray Butler, of Columbia University.

The committee on the semi-centennial celebration is attempting to arrange a meeting distinguished not only for its scientific program, but marked also by a birthday spirit of good fellowship. A particularly festive occasion will be the "Birthday" dinner, at which the society will honor its principal founder and first secretary, Professor Emeritus Thomas Scott Fiske, of Columbia University, who more than any other one person was responsible for the organization of the New York Mathematical Society at a meeting of six persons on November 24, 1888. It was this organization which six years later changed its name to the American Mathematical Society.

In connection with the meeting, there will be an exhibit of mathematical manuscripts, books, models and instruments, arranged by Professor David Eugene Smith.

SCIENTIFIC NOTES AND NEWS

A MEETING of the representatives of the American and British Associations for the Advancement of Science was planned prior to the Cambridge meeting of the British Association at Lord Rayleigh's Chelmsford estate. A discussion was proposed concerning cooperation between the two associations, and perhaps with the corresponding associations of other nations, on international scientific relations, more

especially problems arising from the impact of science on the social order. The American delegates included Professor George D. Birkhoff, retiring president of the American Association, and Dr. F. R. Moulton, permanent secretary. In addition to Lord Rayleigh, president, the British Association representatives included Dr. J. J. R. Howerth, secretary of the British Association, and Sir Richard Gregory, editor of *Nature*.

AMERICANS on the program of the meeting of the British Association for the Advancement of Science now meeting at Cambridge include: Dr. Harlow Shapley, Paine professor of practical astronomy and director of the Harvard College Observatory, "Metagalactic Gradients and the Expanding Universe Hypothesis"; Dr. R. W. Wood, professor of experimental physics at the Johns Hopkins University, "Diffraction Gratings for Astrophysical Purposes"; Dr. J. H. Van Vleck, professor of physics at Harvard University, "The Molecular Field and the Determination of Very Low Temperatures," and Dr. George D. Birkhoff, Perkins professor of mathematics and dean of the Faculty of Arts and Sciences of Harvard University, "Analytic Deformations."

THE honorary degree of doctor of science was conferred by the University of Oxford in July on Dr. Harvey Cushing, Sterling professor of neurology emeritus of Yale University and Moseley professor of surgery emeritus at the Harvard Medical School. Before the ceremony a luncheon was given in his honor by the vice-chancellor of the university.

IN addition to the election as foreign associates of the Paris Academy of Sciences of Professor T. H. Morgan and Sir William Bragg, already announced in SCIENCE, *Nature* reports the election of Professor T. Levi-Civita, emeritus professor of mechanics in the University of Padua.

DELEGATES attending the recent conference of the International Medical Congress for Psychotherapy, which met at Oxford during the last week in July, paid tribute to Professor Freud, who recently left Austria and has taken up his residence in London. In a telegram sent to him the delegates said: "We recognize our indebtedness to you for your brilliant contributions to psychological medicine, and wish you health, happiness and tranquility in your new surroundings in England."

DR. ARTHUR C. CHRISTIE, surgeon, formerly president of the Medical Society of the District of Columbia, has received the second Dr. Frank E. Gibson Award in recognition "of meritorious contributions to medical science." The prize is presented by the Washington Medical and Surgical Society and is named in honor of Dr. Gibson, permanent treasurer of the society.

DR. HERBERT F. PRYTHERCH, director of the Beaufort, N. C., laboratory of the U. S. Bureau of Fisheries, has been awarded the gold medal of the North Carolina Academy of Science for his paper on "The Life Cycle of a Sporozoan Parasite of the Oyster," presented at the 1938 meeting of the society in Raleigh.

THE Keith Prize of the Royal Society of Edinburgh has been awarded to Dr. H. S. Ruse, professor of pure and applied mathematics at University College, Southampton, for his paper "On the Geometry of Dirac's Equations and their Expression in Tensor Form" and for other papers. The Neill Prize has been awarded to Professor William J. Hamilton, St. Bartholomew's Hospital Medical College, for his contributions to the embryology of the ferret and other work.

Nature reports that the Gold Medal of the British Institution of Mining and Metallurgy has been awarded to Professor S. J. Truscott, "in recognition of his services in the advancement of the science and practice of mining and metallurgy, with special reference to his services in technological education." The Consolidated Gold Fields of South Africa, Ltd. Gold Medal has been awarded to Professor H. V. A. Briscoe, "in recognition of his researches on the sampling and properties of industrial dusts"; the Consolidated Gold Fields of South Africa, Ltd. Premium of forty guineas has been awarded conjointly to Dr. Janet W. Matthews, P. F. Holt and Miss Phyllis M. Sanderson, "in recognition of their work, in association with Professor H. V. A. Briscoe, on the sampling and properties in industrial dusts."

PROFESSOR THOMAS BENJAMIN DAVIE, professor of pathology in the University of Bristol, has been appointed to the George Holt chair of pathology from October 1, in succession to Professor J. H. Dible, now professor of pathology in the Post-graduate Medical School, London.

DR. CLOVIS VINCENT, head of a private clinic for brain surgery in Paris, has been appointed to a newly established chair of brain surgery in the School of Medicine of the University of Paris.

DR. T. G. DELBRIDGE, manager of the Research and Development Department of the Atlantic Refining Company, Philadelphia, has been elected president of the American Society for Testing Materials. W. M. Barr, chief chemical and metallurgical engineer of the Union Pacific Railroad Company, has been elected vice-president.

DR. GUSTAVUS AUGUST EISEN, formerly curator of the California Academy of Sciences, later connected

with the U. S. Department of Agriculture, celebrated his ninety-first birthday on August 2.

DR. FRANCOIS A. GILFILLAN, professor of pharmacy in the School of Pharmacy of the Oregon State College, has been appointed dean of science at the college. He succeeds Dr. E. L. Packard, who has become dean of general research for the state system of higher education and has been made director of the Institute of Marine Biology. Dr. Packard will also continue as head of the department of geology at the college.

DR. J. L. DEEN, associate professor of silviculture at the Pennsylvania State College, and N. A. Christensen, of the California Institute of Technology, have been appointed deans of the schools of forestry and engineering, respectively, of the Colorado State College.

AT the University of Maryland, Fred H. Leinbach has been appointed professor of animal husbandry to succeed K. A. Clark, who recently accepted the managership of Oldfields Farm at Galena. James B. Outhouse has been made instructor and assistant in the department of animal husbandry. Dr. Kenneth L. Turk, assistant professor in the extension department of animal husbandry at Cornell University, has been appointed professor of dairy husbandry, to succeed Professor L. W. Ingham, who recently accepted a position at the National Farm School at Doylestown, Pa.

DR. CLIFFORD S. LEONARD, for the past ten years a director of research in the pharmaceutical industry, has been appointed assistant professor of pharmacology in the College of Medicine of the University of Vermont.

HORACE J. ANDREWS, of the U. S. Forest Service, who has been in charge of a survey of the forest resources of the Pacific Northwest, has been appointed Charles Lathrop Pack professor of wild land utilization in the School of Forestry and Conservation of the University of Michigan. The work will be conducted as an expansion of the activities of the George Willis Pack Forestry Foundation directed by Professor W. F. Ramsdell and will be closely associated with related activities in the university, particularly in the Horace H. Rackham School of Graduate Studies.

DR. RALPH HOWARD FOWLER, fellow of Trinity College, has been reelected to the John Humphrey Plummer professorship of mathematical physics at the University of Cambridge. The London *Times* writes that Professor Fowler resigned from this chair on his acceptance of the directorship of the National Physical Laboratory on the resignation of Professor W. L. Bragg, but that he had been advised to withdraw his acceptance of this post for reasons of health, and signified willingness to be reelected as professor of mathematical physics.

PROFESSOR MORROUGH P. O'BRIEN, chairman of the department of mechanical engineering of the University of California, has been appointed a civilian member of the U. S. Beach Erosion Board.

JAMES F. WILSON, associate professor of animal husbandry in the College of Agriculture at Davis of the University of California, has been made technical adviser to the committee on wool and other animal fibers of the American Standards Association.

HOWARD J. KUMIN, who has been employed by the Division of Fishery Industries in the collection of fishery statistics during the past two years, has resigned from the bureau to become a member of the Bureau of Biological Survey.

THE retirement is announced of Thomas Athol Joyce, since 1932 deputy keeper in charge of the subdepartment of ethnography of the British Museum. He was appointed in 1902 to the staff of the British Museum in the department of British and medieval antiquities and ethnography.

DR. GEORGE L. CLARK, professor of chemistry at the University of Illinois, has returned from a five months' leave of absence spent in Europe. He visited forty university and institutional laboratories conducting x-ray work in Italy, Switzerland, France, Germany, Austria, Czechoslovakia, Holland, Belgium, England and Scotland. He also represented the United States on the occasion of the celebration in Berlin of the eightieth birthday of Professor Max Planck.

WILLIAM D. CAMPBELL, field representative of the American Museum of Natural History, sailed on the Italian liner *Conte di Savoia* on August 6. He plans to make a six months' expedition to Africa to collect specimens to be added to groups in Carl Akeley African Hall at the museum. Members of the party will be Major W. V. D. Dickinson and Robert Kane, of the department of arts and preparations, who will assist in preservation of specimens and the preparation of backgrounds for the habitat groups.

A MEETING of the American Society of Photogrammetry will be held in New York on September 8 and 9 at the headquarters of the American Geographical Society. Developments in commercial photographic equipment for map-making by aeroplane will be described and exhibited. All available floor space of the society will be taken up by special exhibits. Included among subjects to be discussed at the meeting are recent developments in papers, emulsions and lens filters, the ideal aeroplane for aerial survey purposes, photographic principles and their application in aerial photography.

THE fiftieth anniversary of the founding of the Vir-

ginia Agricultural Experiment Station at the Virginia Polytechnic Institute, Blacksburg, Va., was celebrated on July 27 at a meeting held in conjunction with the Institute of Rural Affairs. The following program, presided over by Dr. John R. Hutcheson, director of the Virginia Agricultural Extension Division, was presented: "Some Results of Research at the Virginia Agricultural Experiment Station," by Director A. W. Drinkard, Jr.; "Some Results of Research at the Virginia Truck Experiment Station," by Director H. H. Zimmerley, and "The Place of Research in Planning for Rural Living," by Dean W. C. Coffey, of the University of Minnesota.

THE first program devoted to internationalism in science with the object of interpreting the dangers confronting freedom of scientific thought was broadcast by "Adventures in Science" over the Columbia network on August 12. Professor Edwin G. Conklin, of Princeton University, outlined specific situations that exist in which scientific men and the scientific method of approaching problems are being restricted by war and political attitudes. Appearing on the program with Professor Conklin was Dr. Paul B. Sears, formerly of the University of Oklahoma, who was recently appointed professor at Oberlin College. "Adventures in Science" is one of the adult education series, presented under the guidance of the Adult Education Board of the Columbia Broadcasting Company, of which Dr. Lyman Bryson, professor of education at Teachers College, Columbia University, is the chairman.

A CABLE from San Juan, Puerto Rico, to *The New York Times* states that according to a message received by Governor Blanton Winship from Frederick Coykendall, chairman of the board of trustees of Columbia University, the cooperation of the university with the University of Puerto Rico in the School of Tropical Medicine will be continued. This had been threatened by recent legislation eliminating the representation of Columbia University on the board of trustees. The message was in answer to one from Governor Winship giving assurance that the provisions of the bill eliminating Columbia University were an "error" which would be corrected.

DISCUSSION

THE VENOMOUS EFFECTS OF SOME ARIZONA SCORPIONS

DR. BAERG[1] states that the relative harmlessness of scorpions in the United States is generally known. It seems that this statement ought not to go unchallenged. More lives have been lost in Arizona from the sting of the scorpion than from the bite or sting of any other venomous arthropod or reptile at least during the nine-year period since 1929. For a period of six and one half years, beginning with 1929, there were recorded twenty-five deaths resulting from the sting of the scorpion and only ten deaths caused by the rattlesnake, gila monster and other poisonous animals. Most of the deaths due to scorpion sting have occurred in the southern part of the state, particularly in the Salt River Valley, and the victims have been children usually six years of age and under. The writer knows of one case in which an eight-year-old child succumbed to a scorpion sting.

In and around Mesa, Ariz., one commonly finds two species of scorpions, *i.e.*, *Vejovis spinigerus* (Wood) and *Centruroides sculpturatus* Ewing. A third species less commonly taken is *Hadrurus hirsutus* Wood, the giant hairy scorpion.[2]

The effect of the venom of these scorpions was tested on white rats (the Wistar strain) by permitting the scorpion to sting the experimental animal, usually in the hind foot where there is little or no fur and local reactions can more readily be observed. The sting of *H. hirsutus* caused a swelling in the region of the sting so that the toes were about twice their normal size. In the case of *V. spinigerus* a swelling likewise occurred, but it was not nearly so great as that produced by *H. hirsutus*. Other than the swelling none of the rats showed further effects from the venom of either of these two species. A slight nervousness was observed, but this was attributed to fright rather than to the venom. After about the first five minutes the rats did not even avoid walking with the swollen foot, but the foot was sensitive, more so than the others, when touched with forceps. Within two or three hours all signs of the sting had disappeared.

In the case of the third species, *C. sculpturatus*, no local swelling was noticeable, although the foot was favored, but the reaction seemed to be general and neuropathic. Death occurred within a period varying from ten minutes to one and one half hours. A general description of events from the time of the sting until death may be stated as follows. Within one or two minutes after the sting the rat shows signs of nervousness by a gentle alternate patting of the front feet on the floor of the cage. Then there appears to be an itching in the nose as the rat frequently goes through vigorous cleaning reactions over that region. Soon the animal begins to sneeze and the nose drips a colorless fluid. This symptom reminds one of a

[1] W. J. Baerg, *Natural History*, 42: 1, 42, June, 1938.

[2] Tentatively determined from H. E. Ewing's key in "The Scorpions of the Western Part of the U. S." No. 2730 of the Proceedings of the U. S. National Museum, Vol. 73, Art. 9, pp. 1–24, 1928.

severe case of hay fever. The sneezing continues and finally develops into convulsive reactions. At this time the animal is very sensitive to touch, so that if even the fur is lightly touched the animal jumps and squeals. Salivation begins with the sneezing and continues so that the mouth becomes quite frothy. At about this time the animal will insert its toes within its mouth as though trying to dig out some object in its throat. In many of the cases urination and defecation result. The eyes are dull and glassy. In some animals the nose bleeds. The hind legs become paralyzed. Finally the animal falls on its side, breathes heavily and then gradually succumbs. Death seems to be due to edema of the lung.

In the children observed the reactions of the victims of *C. sculpturatus* are very similar to those shown by the white rat but extend over a greater period of time. In the case of the eight-year-old child noted above, death occurred within seven hours after the sting. *V. spinigerus* sting causes a local redness and swelling in the region of the sting. Sometimes a small white spot appears around the sting in addition to the above reactions. The writer has not observed any case of *H. hirsutus* sting in man.

Upon request, the Institute of Hygiene of the Department of Public Health, Popotla, D. F., Mexico, graciously sent gratis two ampullae of their antiscorpion serum prepared for use on victims of *C. suffusus* and *C. noxius,* two deadly Mexican scorpions. This serum was tried on rats stung by *C. sculpturatus* and found effective, even though the animals were in advanced stages of poisoning. Since then the serum has been tried on human victims of *C. sculpturatus.* In all cases it has proved entirely effective, and no deaths have resulted from scorpion sting, even though the serum was used in quite advanced stages of poisoning.

H. L. STAHNKE

IOWA STATE COLLEGE AND
MESA UNION HIGH SCHOOL,
MESA, ARIZ.

STIMULATION OF KUDZU CUTTINGS

IN view of its desirable growth characteristics in soil conservation work, kudzu is an important plant in the South. However, successful propagation of this plant from seeds and cuttings on a large scale has been limited.

In October, 1937, the Horticultural Department of the University of Georgia and the Soil Conservation Service, in Athens, started a cooperative project for the study of kudzu propagation. In the first greenhouse trial, three commercial synthetic hormone products were used at recommended dilutions for recommended durations. The results given in Table I were obtained after fourteen days.

TABLE I

Commercial product	No. set out	No. rooted	No. unrooted	Per cent. of cuttings rooted
'A' Dilute	75	51	22	68
'A' Standard ..	75	64	11	85
'B' Dilute	75	46	24	61
'B' Standard ..	75	47	27	63
'C' Dilute	72	48	23	67
'C' Standard ..	75	39	27	52
Untreated	75	38	33	51

The results from this trial indicated that cuttings treated with hormones produced a higher percentage of strikes than untreated ones. However, the most noticeable effect was the increase in size and number of roots per cutting. This indication was considered sufficient to justify a second trial, using the material that had given the best results. In addition to this superior hormone product, it was decided to include a comparative test using potassium permanganate, one ounce to eight gallons of water for thirty minutes, which had given good results in previous tests with ornamentals. The results obtained after a thirty-day period are given in Table II.

TABLE II

	No. planted	No. rooted	No. unrooted	Per cent. rooted
Check no. treatment	302	128	174	42.4
'A' Standard	300	160	140	53.3
'A' Standard + ...	150	90	60	60
'A' Standard + + ...	299	127	172	42.5
Potassium Permanganate ..	150	129	21	86

The second trial confirmed the indications of the first in that the treated rooted cuttings showed an increase in the number and size of roots over the untreated ones. The indications are that the potassium permanganate is superior to any hormone product yet tested for kudzu, both as to percentage of strike and size and number of roots developed. The stimulating results obtained through the use of potassium permanganate warrant further studies.

M. C. MYERS
ROY A. BOWDEN

HORTICULTURAL DEPT.,
UNIVERSITY OF GEORGIA

F. E. HARDISTY

SOIL CONSERVATION SERVICE,
ATHENS, GEORGIA

"A CROSS-SECTION OF OUR TIME"

As part of its activity in connection with the New York World's Fair of 1939 the Westinghouse Company is considering the preservation of a "Cross-section of our Time" in a large capsule of copper alloy, to be deposited deep in the earth at the site of the fair, with proper ceremony, some time late in September of this year. The capsule, which has engaged considerable engineering and metallurgical attention, is to be so constructed as to last 5,000 years. The articles

in the interior, which are being selected with the advice of archeologists, historians, technical societies and others, are to be preserved in an inner glass crypt, filled with nitrogen or other inert gas.

Though the interest and cooperation of many scientific men has already been obtained through personal interview and by letter, we feel that the project needs and merits the suggestions and advice of as large a cross-section of the scientific community as possible. Many questions present themselves, such as: What method should be used for the preservation of the items in the "Time Capsule"? Should books be reduced to microfilm, and will this last? What books, what small physical objects, what pictures, etc., will best present a picture of ourselves and our times to the people of *circa* 6939? What key to our language may we leave which will enable them to translate and understand what is in the capsule? How best may we leave word of the location of this capsule for the archeologists of such a distant future?

We welcome suggestions on these and other questions. As time is short, we urge scientific men to let us have at once their thoughts on this project.

D. S. YOUNGHOLM,
Vice-president, Westinghouse Electric and Manufacturing Company

SOCIETIES AND MEETINGS

THE KANSAS ACADEMY OF SCIENCE

THE seventieth annual meeting of the Kansas Academy of Science was held at the Kansas State Teachers College, Pittsburg, March 31, April 1 and 2, 1938. Cooperating with the academy and meeting at the same time was held the thirty-fourth annual meeting of the Kansas Association of Teachers of Mathematics under the chairmanship of Miss Anna Marm, of Lindsborg; The Kansas Section of the Mathematical Association of America under the leadership of Vice-president C. B. Tucker, of Emporia; the Kansas and Nebraska chapters of the American Association of University Professors, with Professor D. A. Worcester, Lincoln, Nebraska, regional chairman; and the Kansas Entomological Society, which is affiliated with the academy as the section on entomology under the leadership of Vice-president L. C. Woodruff, Lawrence.

Dr. Leo Christiansen addressed the first meeting on Thursday evening under the joint auspices of the South East Kansas Section of the American Chemical Society and the academy on "The Farm Chemurgic." Academy business sessions of an hour each were held on Friday and Saturday mornings on April 1 and 2. The remainder of the time during the two days was devoted to section meetings. A section on geology and one for science teachers were organized during the year and met as sections for the first time. Table I presents a report of the sessions.

The senior and junior banquets were held on Friday evening at the college cafeteria with an attendance of 180 at the senior banquet and 125 at the junior academy banquet. Dr. W. H. Schoewe, president-elect, served as toastmaster. President W. A. Brandenburg, of the college, responded with an address of welcome to the two groups. Professor George A. Dean gave the president's address on the subject, "The Contributions from Kansas to the Science of Entomology." The group then adjourned to the college auditorium to hear the annual invitation address, given this year by Dr. Lawrence H. Snyder, professor of zoology, Ohio State University, on the subject, "Heredity and Human Affairs," before an audience of approximately five hundred.

TABLE 1

Section	Chairman	No. of papers	Total attendance	Chairman for 1938–1939
Botany	Miss Margaret Newcomb	28	40	C. C. McDonald, Wichita
Geology	J. M. Jewett	16	47	D. C. Schaffner, Emporia
Psychology	O. W. Alm	17	75	Joseph W. Nagge, Emporia
Zoology	C. E. Burt	29	75	Earl H. Herrick, Manhattan
Physics	C. V. Kent	11	35	Penrose Albright, Winfield
Chemistry	Lloyd McKinley	10	60	Fayette T. Owen, Emporia
Junior Academy	Oscar Klingman		300	Bill Akey, Pittsburg
Kansas Entomological Society	L. C. Woodruff	16	35	L. C. Woodruff, Lawrence
Science Teachers	W. J. Baumgartner	9	125	Lorene Bailey, Parsons, Biology Lawrence Oncley, Winfield, Phy. Sciences
Mathematical Association of America	Chas. B. Tucker	4	50	Chas. B. Tucker, Emporia
Kansas Association of Teachers of Mathematics	Miss Anna Marm	2	75	Miss Minnie Stewart, Topeka
University Professors	D. A. Worcester	7	50	D. A. Worcester, Lincoln, Nebr.

Trips to the strip coal mines, deep mines and a coal washer near Pittsburg, Kansas, were arranged for members and visitors. Progress in reclaiming former strip coal land was pointed out.

Committee progress was indicated in reports at the business meeting. The committee on natural areas prepared a descriptive illustrated pamphlet on "Rock City," an area of most unusual rock formations near Minneapolis, Kansas, which the committee hopes to preserve for posterity by means of a state or national monument. The pamphlet was widely distributed, and the rock city project has attracted attention in other states. The committee on science teaching in the secondary schools, with Dr. O. W. Alm, Kansas State College, chairman, made a survey of the subject in 235 high schools in cities of first, second and third classes and prepared an extended report of their findings for publication. The membership committee reported 180 new members during the year, with 740 on the membership roll. The committee on research awards, with Dr. L. D. Wooster, chairman, made the following awards for the ensuing year: To Dr. Edwina A. Cowan, director of the Child Research Laboratory, Friends University, Wichita, $40 from the American Association for the Advancement of Science and academy funds, for the purchase of a chronoscope to assist in her studies on constitutional types of children; to Dr. Frank C. Gates, Kansas State College, Manhattan, $42.50 from the academy treasury for assistance in the study of the distribution of flowering plants and ferns of the state; to Dr. John Breukelman, Kansas State Teachers College, Emporia, $32.50, which is award No. 2 of the Albert B. Reagan endowment fund for aid in his studies on the distribution of Kansas fishes; to Professor H. R. Bryson, assistant professor of entomology, Kansas State College, $25 from the A. A. A. S. fund to pay for drawings of Elateridae of Kansas; to Dr. Mary T. Harman, professor of zoology, Kansas State College, $42.50 from the academy fund to aid in her studies of the development of pigment in the hair and skin of guinea pigs; and to Dr. Roger C. Smith, professor of entomology, Kansas State College, $25 from the A. A. A. S. fund to pay for photographs of grasshopper eggs. The $75 from the A. A. A. S. was augmented by $100 from the academy treasury, providing a total of $207.50 for research funds for the coming year.

Dr. H. A. Zinszer, the treasurer, was designated representative to the Academy Conference at the Richmond meeting.

Possibly the outstanding accomplishment of the year was made by the Junior Academy of Science committee, which consisted of Dr. J. Ralph Wells, Kansas State Teachers College, Pittsburg, *chairman,* Miss Edith Beach, Lawrence, and J. A. Brownlee, Wichita. They reported a total of 17 affiliated Junior Academy groups, 11 of which were organized since the last meeting. The junior academy meeting consisted of the induction of the 11 new clubs and a full afternoon of individual and group demonstrations. The Lawrence, Jr. High School group was awarded first place and will be given temporary custody of the loving cup to be bought for this recognition.

The American Association of University Professors held two sessions. Dean C. M. Correll, of Kansas State College, was chairman of the morning session at ten o'clock. Dr. C. M. Street presided at the luncheon meeting at twelve thirty. An important action written by the association was the establishment of a committee to bring about closer cooperation between the local chapters within the State of Kansas. The committee is to consist of one member from each chapter. Robert W. Conover, of Kansas State College, was appointed chairman.

The Kansas Academy inaugurated the plan last year of selecting the president a year in advance, thus giving him a preparatory year to think about his plans, aims and committees. Dr. W. H. Schoewe, professor of geology at the University of Kansas, was made president-elect last year and came to the meetings this year with a well-prepared organization plan and a list of carefully selected committee members. He initiated his term as president for the coming year at the business meeting on Saturday. Dr. H. H. Hall, Kansas State Teachers College, Pittsburg, Kansas, was selected as the president for 1939 with the title of president-elect. Other officers elected were as follows: *Vice-president,* Dean E. O. Deere, Bethany College, Lindsborg; *Secretary,* Roger C. Smith, Manhattan; *Treasurer,* H. A. Zinszer, Hays; *Members of the Executive Council,* Geo. A. Dean, Manhattan, Lawrence Oncley, Winfield, and R. H. Wheeler, Lawrence; *Editor,* Frank C. Gates, Manhattan; *Associate Editors,* R. E. Mohler, McPherson, and Robert Taft, Lawrence.

A total of 236 members registered for the meeting. The next annual meeting will be held in Lawrence at the University of Kansas about April 1, 1939.

ROGER C. SMITH,
Secretary

JOINT MEETING OF COLLEGE PHYSICS TEACHERS AT URBANA, ILLINOIS

THE physics teachers of the area outside of Chicago held an organization meeting at the University of Illinois on November 6, 1937. A general committee on arrangements was appointed at the time, consisting of Professor L. I. Bocksthaler, of Northwestern University; Professor R. Ronald Palmer, of James Millikin University, and Professor R. F. Paton, of the University of Illinois.

In the Chicago area such an organization has been in operation for some time. At the suggestion of the down state committee a joint meeting was arranged. This met in the Laboratory of Physics of the University of Illinois on Saturday, April 23, 1938.

A program of ten papers was presented, dealing with the present-day problems of the physics teacher, by representatives from the University of Chicago; Western State Teachers College, Macomb; Eastern State Teachers College, Charleston; the University of Illinois; Woodrow Wilson Junior College, Chicago; and Bradley Institute.

Active interest was expressed throughout, and discussions followed each paper. Among the important recommendations discussed and passed were: (1) Full cooperation with the state committee in its endeavor to raise the teaching standard of physics in the state. (2) The joint session favors that a minimum of 16 hours of college physics be required of prospective high-school teachers of physics; however, that this recommendation should not be immediately applied to teachers already in service.

The attendance was thirty-two. Twenty-one of the leading educational institutions of the state were represented at the meeting. The down state club continued the general committee—Bocksthaler, Palmer, Paton—with instructions to arrange for the next meeting.

CHAS. T. KNIPP,
Secretary

UNIVERSITY OF ILLINOIS

SPECIAL ARTICLES

SOLUTIONS OF CHLOROPHYLL–PROTEIN COMPOUNDS (PHYLLOCHLORINS) EXTRACTED FROM SPINACH

THE differences in solubility, fluorescence and absorption spectrum between the green pigments in the leaf and the chlorophylls extracted in solvents such as alcohol have been ascribed either to dispersion of the green pigments in the leaf, or to adsorption or combination of the chlorophyll with lipoid or protein.[1] We have prepared aqueous solutions of the green pigments which show characteristic protein properties and which resemble the pigments in the leaf. To distinguish them from the chlorophylls we have adopted the name *phyllochlorin* for these chromoproteins, as suggested by Mestre.

Our extracts have been prepared using dilute aqueous digitalin, a solvent currently used for the photosensitive retinal pigments.[2] Ordinary leaf press juice or distilled water extracts show the green pigments not in true solution,[3] but in a fine suspension whose particles are visible under the microscope and can be retained on a fine filter.

About 100 gm of fresh spinach is thoroughly ground with fine sand, water is added to make 100 ml, and the suspension filtered through a coarse fluted filter. The moist cake is reground and again extracted. To the combined extracts is added 5 gm of Filter-Cel.[4] per 100 cc, and the whole is filtered through a thin layer of Filter-Cel. on a Buchner funnel. The deep yellow-brown filtrate is discarded. The cake is washed in distilled water several times until the filtrate shows no trace of yellow color. It is then extracted with 25 ml of 1 or 2 per cent. aqueous digitalin;[5] the result is a dark green solution which shows no trace of suspended material under an oil immersion lens. Similar preparations can be made with 4 per cent. purified bile salts. More dilute extracts are obtained in concentrated (40-50 per cent.) urea solutions. Digitalin solutions of the phyllochlorin kept for some weeks in the cold room (5° C.) show a little precipitated pigment which does not redissolve.

The absorption bands of the phyllochlorin (Fig. 1), measured with Shlaer's spectrophotometer,[6] are like those of the leaf and are shifted towards the longer

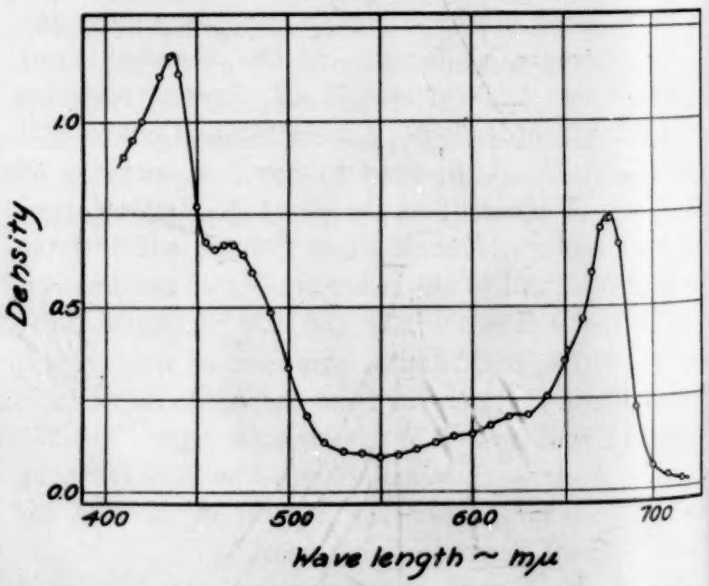

FIG. 1. The absorption spectrum of a phyllochlorin solution prepared with 2 per cent. digitalin and diluted 1 to 10 with distilled water. The density values are for a 5 mm depth of solution.

[1] Reviewed by H. Mestre in "The Investigation of the Pigments of the Living Photosynthetic Cell," in Contributions to Marine Biology, Stanford University Press, 1930.

[2] *e.g.*, K. Tansley, *Jour. Physiol.*, 71: 442, 1931; A. M. Chase and C. Haig, *Jour. Gen. Physiol.*, 21: 111, 1938; G. Wald, *Nature*, 140: 545, 1937.

[3] T. B. Osborne and A. J. Wakeman, *Jour. Biol. Chem.*, 42: 1, 1920. Such suspensions have also been studied by V. Lubimenko, *Rev. Gen. de Bot.*, 39: 547, 1927; and B. Hubert, *Rec. trav. bot. néerl.*, 32: 324, 1935.

[4] Filter-Cel., Johns-Manville, New York.

[5] Crystalline digitalin, Eimer and Amend, New York.

[6] S. Shlaer, *Jour. Opt. Soc. America*, 28: 18, 1938.

wave-lengths as compared with the natural mixtures of chlorophyll *a* and *b*.[7] The three bands are at 437, 470 and 675 mμ, while those for chlorophyll are at 420, 465 and 660 mμ. The 420 and 660 mμ maxima of chlorophyll have about the same height, while for phyllochlorin solutions the 437mμ maximum is always 60 per cent. higher than the 674 band. This suggests the presence of carotenoids associated with phyllochlorin, such as French[8] found for the chromoprotein solutions from photosynthetic purple bacteria.

Boiling a neutral digitalin extract shifts the red absorption band towards the shorter wave-lengths. When a solution is made strongly acid or weakly acid and boiled, the solutions turn yellow, corresponding to the formation of phaeophytins. A digitalin extract saturated with solid ammonium sulfate precipitates the phyllochlorin only after several days, but when boiled forms a bright green viscous mess. No pigment is lost on prolonged dialysis (about two weeks) of a digitalin extract, and only a part of the pigment precipitates. This precipitate, separated by centrifuging, does not readily redissolve in digitalin solution. The pigment which remains in solution is now readily precipitated with high concentrations of ammonium sulfate. Such precipitates are easily redissolved in digitalin solution but not in water. It is likely that the solvent action of the digitalin and the bile salts is due to the formation of coordination compounds which are not broken up even on prolonged dialysis. Phyllochlorin is precipitated and the chlorophyll extracted by strong alcohol, methyl alcohol or acetone but not by petroleum ether in agreement with the effects of these solvents on the leaf. Phyllochlorin solutions show a positive Biuret reaction.

In agreement with observations of the green leaf, phyllochlorin solutions show little or no red fluorescence when irradiated with blue light (436 mμ). This is in contrast with the strong red fluorescence of alcoholic chlorophyll solutions. Phyllochlorin solutions are quite stable to visible light.

The behavior of phyllochlorin solutions in strong centrifugal fields is being investigated in collaboration with Dr. E. G. Pickels[9] using an air-driven ultracentrifuge.[10] Preliminary studies show that the phyllochlorin when subjected to a force of 160,000 gravity can be sedimented completely through a 10 mm column of the liquid medium within three hours, leaving no color in the supernatant fluid. Our best preparation showed two sedimentation boundaries which correspond to particles of high molecular weight, *i.e.*, above 70,000. The two boundaries retained their identity with respect to their sedimentation rates when studied by the light absorption method in the red and blue regions corresponding to the absorption maxima of phyllochlorin in the visible, and in the ultra-violet region characteristically absorbed by proteins. One boundary sedimented almost twice as fast as the other; these more rapidly moving and presumably heavier particles showed a greater total absorption in each of the two regions of the visible spectrum than did the smaller particles.

It is tempting to assume that these two proteins correspond with phyllochlorins *a* and *b*. The similarity of sedimentation properties throughout the spectrum indicates that the additional blue absorption is characteristic of the phyllochlorins and not of some other component.

It now appears that the classical organic chemical studies of the chlorophylls and carotenoids were concerned with the prosthetic groups of extremely complex specific catalysts, perhaps analogous to the hemoglobins and enzymes such as cytochrome, catalase and the yellow respiratory enzyme. Presumably there are many additional components concerned in photosynthesis, since phyllochlorin does not carry on photosynthesis *in vitro*.

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[7] *c.f.* E. Rabinowitch and J. Weiss, *Proc. Roy. Soc. London*, A, 162: 251, 1937.

[8] C. S. French, Abstract in the Proceedings of the American Society of Biological Chemists, Baltimore meeting, March 30–April 2, 1938.

[9] Of the Laboratories of the International Health Division, The Rockefeller Foundation, New York.

[10] J. H. Bauer and E. G. Pickels, *Jour. Exp. Med.*, 65: 565, 1937.

OVINE AND BOVINE LISTERELLOSIS IN ILLINOIS

THE pathogenesis of organisms of the genus Listerella and their possible etiologic significance in rodent septicemia have been reported in England[1] and South Africa,[2] while in New Zealand[3] sheep suffering from an encephalitic syndrome, designated "circling disease," has been associated with or attributed to Listerella infection. In the United States, Listerella has been isolated from cattle,[4] sheep[5] and man,[6,7] displaying symptoms of encephalitis, and from chickens[8] that disclosed lesions of necrotic myocarditis. So far as

[1] E. G. D. Murray, R. A. Webb and M. B. R. Swann, *Jour. Path. and Bact.*, 29: 407, 1926.

[2] J. H. H. Pirie, *So. African Inst. Med. Res.*, 3: 163, 1927. Cited by Gill.

[3] Dudley A. Gill, *Vet. Jour.*, 87: 60, 1931 and 89: 258, 1933; *Australian Vet. Jour.*, 13: 46, 1937.

[4] F. S. Jones and R. B. Little, *Arch. of Path.*, 18: 580, 1934.

[5] Erwin Jungherr, *Jour. A. V. M. A.*, 91: 73, 1937.

[6] Caspar G. Burn, *Jour. Bact.*, 30: 573, 1935; *Am. Jour. Path.*, 12: 341, 1936.

[7] E. W. Schultz, M. C. Terry, A. T. Brice and L. P. Gebhardt, *Proc. Soc. Exp. Biol. and Med.*, 31: 1021, 1934. Cited by Burn.

[8] C. V. Seastone, *Jour. Exp. Med.*, 62: 203, 1935.

we are aware, listerellosis in sheep and cattle showing an encephalitic and/or an encephalomyelitic syndrome has not been reported in central United States. However, Doyle[9] described an idiopathic encephalitis of sheep in Indiana accompanied by gross and microscopic changes in the brain analogous to ovine Listerella infection encountered in Illinois during the winter of 1937–38.

In this paper reference is made to two outbreaks of ovine and one outbreak of bovine encephalitis and/or encephalomyelitis associated with Listerella. The first outbreak coming to the attention of the Illinois Agricultural Experiment Station occurred in a group of 250 feeder lambs that had been purchased at a central market. Lambs of this type for fattening generally originate in western grazing states, but the origin and history of the animals comprising this shipment were not determined. Approximately six weeks following arrival of the lambs on a farm in DeWitt County, Ill., symptoms of illness developed. The symptoms consisted of depression, weakness, incoordination, fever, walking in circles, pushing against objects with the head, anorexia and progressive paralysis, terminating in coma and death. Approximately 30 lambs died or became moribund and were destroyed and a few mildly affected lambs apparently made a complete recovery. An ophthalmia of transitory nature was noted in some of the mildly affected lambs. The same lesion was also observed at autopsy of fatally affected lambs.

Five of the typically affected lambs from this flock came to autopsy. Each yielded Listerella-like organisms from the brain stem on liver agar plates and/or in tubes of meat mash media incubated at 37.5° C. Bacteriologically sterile brain tissue filtrates (Berkefeld N) proved negative to demonstrable virus upon intracerebral inoculation of rabbits, guinea pigs and chickens.

The second outbreak occurred in a flock of 100 breeding ewes in DeWitt County, but so far as determined, had no connection with the first outbreak. A small number of the breeding ewes in this flock displayed symptoms involving the central nervous system with a mortality of six ewes. One of the clinically affected animals was submitted for observation and autopsy. An organism possessing characters of the genus Listerella was iolated from the brain stem.

A third outbreak showing an encephalitic and/or encephalomyelitic syndrome was observed in a group of 60 yearling feeder steers in Piatt County, Ill. The principal symptoms were glassy, dazed expression of eyes, partial paralysis of mandible, elevation of the head and salivation. Affected animals became prostrate and remained comatose for three to four days before death. Listerella-like organisms were isolated from the brain stem of two fatally affected steers.

Postmortem examination of naturally affected lambs and ewes in two outbreaks did not reveal any marked gross pathologic changes in the internal organs. In some of the lambs the cervical and visceral lymph nodes were enlarged and slightly edematous. There was an increased amount of slightly cloudy cerebrospinal fluid with slight congestion of the meninges. In one case gross lesions suggestive of a localized meningitis were noted. The blood picture of five of the natural ovine cases did not show any significant deviation from the normal.

An examination of stained sections from the brain of naturally affected lambs and cattle showed polymorphonuclear and mononuclear foci in the stem and in the white matter of the cerebrum and cerebellum, together with perivascular cuffing with mononuclear cells and a mononuclear meningitis.

The pathogenic properties of Listerella strain isolated from one outbreak in sheep have been established by artificial exposure of healthy lambs, calves, chickens, guinea pigs, rabbits and rats, while cultural and biochemic properties of the strains from the three outbreaks described herein conform to the genus Listerella. It appears that three natural outbreaks (two in sheep and one in cattle) in Illinois, accompanied by symptoms of encephalitis and/or encephalomyelitis, were associated with Listerella infection.[10]

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THE EFFECT OF NUCLEOPHOSPHATASE ON "NATIVE" AND DEPOLYMERIZED THYMONUCLEIC ACID

IT has been definitely established that desoxyribonucleic acids differ in their molecular weight, depending upon their method of preparation. The substance prepared by E. Hammarsten[1] seems to be the un-

[9] L. P. Doyle, *Jour. A. V. M. A.*, 81: 118, 1932.

[10] After dictating the above report on the occurrence of Listerellosis in cattle and sheep in Illinois, attention was called to an article on "Listerella Infection in Fowls in East Anglia" by Dr. J. Stuart Paterson, Institute of Animal Pathology, Cambridge University, published in *Veterinary Record* 49: 49, 1937, with reference to spontaneous Listerella in four separate groups of fowls, as follows:

a. Two adult fowls were involved, and in both cases death occurred suddenly.

b. One hundred and twenty out of 200 Leghorn pullets died during a period of three months. In addition to the presence of organisms of the Listerella group, *B. pullorum* was recovered from some of the pullets and there was also a heavy infestation of tapeworms (*Davainea proglottina*).

c. Four hundred pullets and 24 stock cockerels comprised the affected unit. The losses were 190 pullets and one cockerel. In several of the pullets from which Listerella were recovered, lesions of fowl paralysis (neurolymphomatosis) were also present.

d. Eight out of 24 young poultry died.

[1] E. Hammarsten, *Biochem. Zeits.*, 144: 383, 1924.

changed acid as it occurs in the cells of the thymus gland and of fish sperm (in combination with histone in the former and with protamine in the latter); according to investigations with various methods[2] (filtration and ultracentrifugation) its molecular weight is approximately 1,000,000. It may therefore be referred to as the "native" desoxyribonucleic acid.

Thus far the molecular weight has been determined definitely for the "native" nucleic acid only. Complete depolymerization of the acid to a single tetranucleotide has not yet been accomplished by chemical means.

On the other hand, by a specific enzyme obtained for the pancreas gland, Feulgen[3] succeeded in transforming the "native" nucleic acid to a tetranucleotide which differs from the "native" nucleic acid in certain physical properties and which is referred to in the literature as "b" nucleic acid.

In collaboration with Dr. E. G. Pickels,[4] we compared the behavior of "native" and "b" nucleic acid in the ultracentrifugal field with the result that the "b" form did not sediment at all, whereas the "a" form (prepared according to Neumann) settled down in a cleared boundary indicating particles of molecular weights between 200,000 and 1,000,000. These results represent the exact proof for Feulgen's assumption, that the enzymic transformation from "native" nucleic acid into the "b" form is a depolymerization.

Even though the molecular weight of "b" nucleic acid has not yet been determined, still it is not improbable that it represents a single tetranucleotide, for the reason that its behavior towards nucleophosphatase[5] is entirely different from the nucleic acids of higher molecular weight. We now find that the so-called "b" nucleic acid is the only one entirely dephosphorylated by the phosphatase, whereas the "native" desoxyribonucleic acid is not affected by this nuclease at all. Only when contaminated with the depolymerase does phosphatase affect nucleic acids of the high molecular weight.

This find, then, is of significance not only because it brings out an additional step in the process of biological catabolism of nucleic acids, but also because it furnishes a means of testing the purity of "native" nucleic acid, on one hand, and of testing the purity of a nucleophosphatase by means of the native nucleic acid, on the other.

It will be of significance also in connection with other questions bearing on the structure of nucleoproteins.

The method of preparation of nucleophosphatase free from depolymerase will be given in detail elsewhere.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLE RECORDER FOR PHYSIOLOGICAL VOLUME CHANGES

As a sensitive recorder of small changes in volume, the bellows recorder devised by Brodie in 1902[1] has no equal. Its usefulness is limited, however, by the fact that it is tedious to build satisfactorily, especially since the membranes used in its construction are perishable and must be replaced frequently.

We have used in this laboratory for the past year a volume recorder which retains the principle of the Brodie apparatus, yet which can be made air-tight without difficulty, and in which the perishable membrane can be replaced in a few moments. The apparatus has found so many uses in both the student and the research laboratories that it seems to merit a brief description.

The construction of the recorder is shown in the accompanying sketch. The membrane *a* is a light, inelastic balloon, made by tying a commercially prepared sheep's cecum to the lead tube *b*. The sheep's

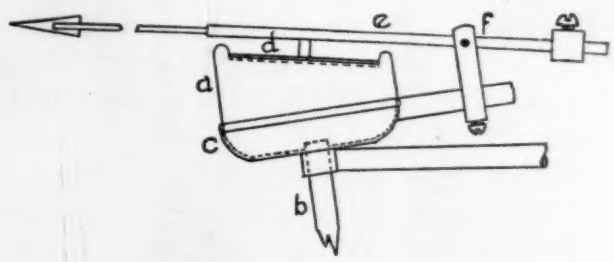

FIG. 1

cecum is sold as a contraceptive sheath. It is softened by soaking in 50 per cent. glycerol solution for a few minutes before tying. The lead tube passes through the center of a metal base, *c*, made concave to conform to the shape of the balloon. The lead tube is of rubber,

[2] R. Signer, T. Caspersson and E. Hammarsten, *Nature*, 146: 122, 1938; W. T. Astbury and F. Bell, *Nature*, 146: 747, 1938.

[3] R. Feulgen, *Zeits. physiol. Chem.*, 237: 261, 1935.

[4] We wish to acknowledge our appreciation to Dr. Pickels for his kind cooperation in this work.

[5] Nucleophosphatase probably consists of two components, one splitting the tetranucleotides into mononucleotides, and one dephosphorylating the latter. In the interest of shortness, we use in this note the term nucleophosphatase for this whole enzyme system.

[1] T. G. Brodie, *Jour. Physiol.*, 27: 473, 1902.

made rigid where it passes through the base by inserting a short segment of glass tubing. It fits the opening in the base snugly, but can easily be drawn up for tying the balloon. The light brass disc, of slightly smaller diameter than the balloon, is firmly attached to the lever *e*, whose fulcrum, at *f*, is adjustable on a rod soldered to the base. The lever is lightly counterpoised beyond the fulcrum. When the balloon has been fitted to its receptacle, it is cemented both to the receptacle and to the brass disc with rubber cement.

In order to smooth out irregularities in the shape of the balloon it has been found desirable to have the lever enough out of balance to raise pressure in the balloon about 5 mm H_2O. If this precaution is taken, there is an almost linear relation between volume change and angular movement of the lever. The range of the recorder is, of course, determined by the volume of the balloon used. Balloons with a volume of about 20 cc have been found satisfactory for most work.

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AN AQUEOUS MEDIUM FOR MOUNTING SMALL OBJECTS[1]

IN the course of investigating a group of small marine copepods the writer has searched for a rapid method of preparing mounts of the parts. Dissecting in glycerin has proved to be very satisfactory, but it was desirable to find a more satisfactory mounting medium than glycerin jelly for the very small parts. Articles recently published in SCIENCE[2,3] called attention to the possible usefulness of corn syrup (dextrose) and mixtures containing it. In following these suggestions, white Karo syrup alone was tried, but it was found to be very difficult to arrange the parts in position in the syrup, even when a very small drop was used; shifting invariably occurred after the cover-glass was added. With this medium it is also difficult to make the mount thin enough for the use of an oil immersion objective.

Dr. Zirkle's note on mounting media for the Belling acetone-carmine technique suggested a modification which has proved to be very satisfactory. The medium used is essentially Zirkle's mixture without the aceto-carmine:

White Karo syrup	5 cc
Certo (fruit pectin)	5 cc
Water	3 cc

A gram of powdered fruit pectin, dissolved in about 10 cc of water by boiling, may be used instead of Certo. A crystal of thymol is added as a preservative.

In making mounts with this mixture a very small drop is taken up with a fine needle and spread out upon a clean slide. The desired parts are immediately transferred to it and arranged as desired; if the drop is spread out rather thin the smallest parts (*e.g.*, copepod mouth parts) may be quite easily arranged. The mixture begins to "set" in about two minutes, and holds the parts firmly in position. If it should set before all the parts are in position, the excess may be scraped away and a fresh drop added. (The rapidity of setting can be controlled by varying the amount of water used in the mixture). When all parts have been arranged, the mount is dried to hardness over heat. If the cover-glass is put in place with another drop of the mixture a slight shifting of the mounted parts takes place, but this difficulty was overcome by adding the cover-glass with a drop of euparal, which does not dissolve the syrup-pectin mixture. The cover-glass can now be pressed down quite firmly without in the least disturbing the parts. An additional advantage of using euparal is that it can be dissolved off with 95 per cent. alcohol, if necessary, and the cover-glass removed without disturbing the parts. The syrup-pectin mount may then be softened by the addition of a fresh drop of the mixture and the objects rearranged, and the cover-glass added as before. It is not necessary to ring the cover-glass. The refractive properties of the syrup-pectin-euparal combination appear to be satisfactory, although the edges of the drop of syrup-pectin mixture appear as very faint lines.

Various small organisms have been mounted in this medium, both with and without euparal, with results quite as good as for the copepod appendages. If the cover-glass is mounted with the syrup-pectin, sufficient mixture must be used to prevent the formation of air pockets under the cover as the medium dries. Mounts made by the above methods have proved to be very satisfactory for study, and are apparently standing up very well, although none are more than ten months old. The rapidity and effectiveness of the method suggest that it may prove valuable to other workers.

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[1] Contributions from the Scripps Institution of Oceanography, New Series, No. 26.

[2] Ruth Patrick, SCIENCE, 83: 85.

[3] Conway Zirkle, SCIENCE, 85: 528.

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